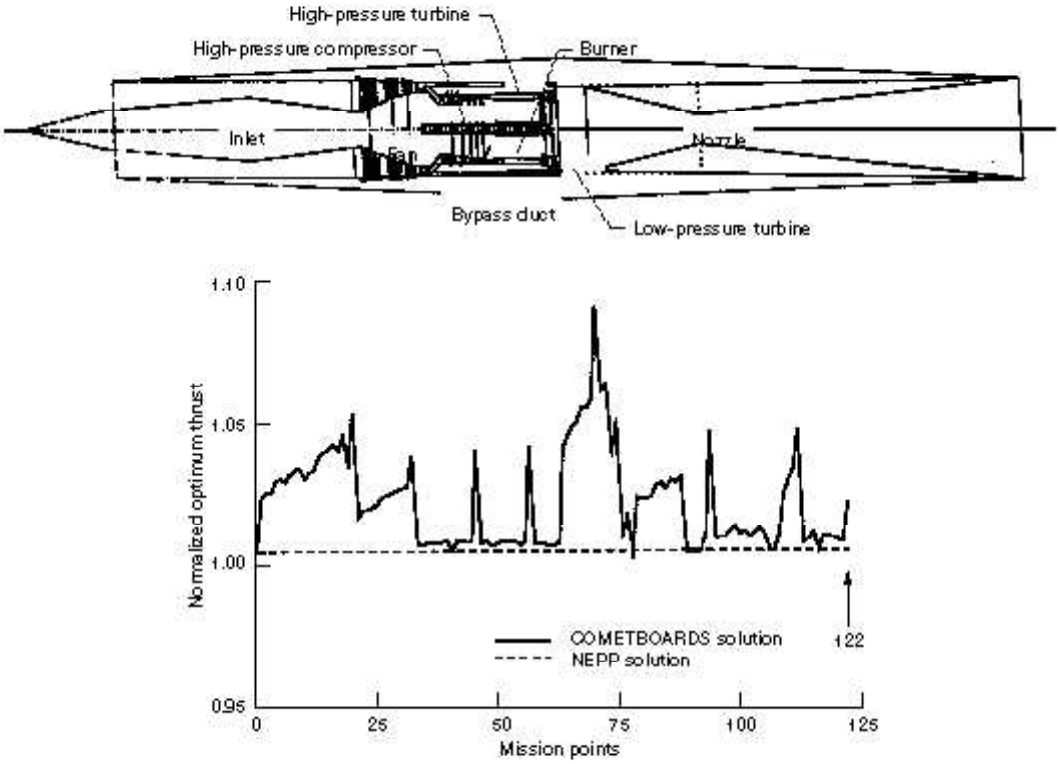
Cascade Optimization Strategy Maximizes Thrust for High-Speed Civil Transport Propulsion System Concept

The design of a High-Speed Civil Transport (HSCT) air-breathing propulsion system for multimission, variable-cycle operations was successfully optimized through a soft coupling of the engine performance analyzer NASA Engine Performance Program (NEPP) to a multidisciplinary optimization tool COMETBOARDS that was developed at the NASA Lewis Research Center. The design optimization of this engine was cast as a nonlinear optimization problem, with engine thrust as the merit function and the bypass ratios, r-values of fans, fuel flow, and other factors as important active design variables. Constraints were specified on factors including the maximum speed of the compressors, the positive surge margins for the compressors with specified safety factors, the discharge temperature, the pressure ratios, and the mixer extreme Mach number.

Solving the problem by using the most reliable optimization algorithm available in COMETBOARDS would provide feasible optimum results only for a portion of the aircraft flight regime because of the large number of mission points (defined by altitudes, Mach numbers, flow rates, and other factors), diverse constraint types, and overall poor conditioning of the design space. Only the cascade optimization strategy of COMETBOARDS, which was devised especially for difficult multidisciplinary applications, could successfully solve a number of engine design problems for their flight regimes. Furthermore, the cascade strategy converged to the same global optimum solution even when it was initiated from different design points. Multiple optimizers in a specified sequence, pseudorandom damping, and reduction of the design space distortion via a global scaling scheme are some of the key features of the cascade strategy.



HSCT engine concept, optimized solution for HSCT engine concept.

The figure depicts a COMETBOARDS solution for an HSCT engine (Mach-2.4 mixed-flow turbofan) along with its configuration. The optimum thrust is normalized with respect to NEPP results. COMETBOARDS added value in the design optimization of the HSCT engine.